

MONTHLY PROGRESS REPORT MONTANA DOT "PERFORMANCE PREDICTION MODELS" SEPTEMBER 2004

To: Susan Sillick, MDT; Jon Watson, MDT
Contract No.: MDT HWY-30604-DT
Contractor: Fugro Consultants LP
Contract Period: June 2001-May 2006
Prepared By: Jim Moulthrop, Project Manager
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PROJECT OVERVIEW

The overall objective of this research is to develop a design process and performance/distress prediction models that will enable the Montana Department of Transportation (MDT) to use mechanistic-empirical principles for flexible pavement design. The project involves a comprehensive performance monitoring and laboratory-testing program and spans a period of five years.

The specific tasks identified in the work plan are:

- PHASE I
 - Task 1. Literature Review
 - Task 2. Review of MDT Pavement-Related Data
 - Task 3. Establish the Experimental Factorials
 - Task 4. Develop Work Plan for Monitoring and Testing
- PHASE II
 - Task 5. Presentation of Work Plan to MDT
 - Task 6. Implement Work Plan – Data Collection
 - Task 7. Data Analyses and Calibration of Performance Prediction Models
 - Task 8. Final Report and Presentation of Results

|| NOTE: New information for the current month is notated by double-lines to the left of text, tables, or figures.

CURRENT WORK ACTIVITIES AND COMPLETED TASKS

PHASE I

Task 1 – Literature Review

Completed: The "Literature Review," summarizing the pavement performance models to be considered within this project, was submitted to MDT in October 2001.

Task 2 – Review of MDT Pavement-Related Data

Completed: A review of the available pavement-related data specific to the State of Montana was completed and included in the Task 3 "Experimental Factorial" and Task 4 "Sampling and Testing Plan" submitted to the MDT in October 2001.

Planned: Because the LTPP database is updated periodically, to ensure the data is accurate and current, Fugro will perform a one-time final update of the calibration/validation database before the end of the project.

Task 3 – Establish the Experimental Factorials

Completed: The "Minimum Data Elements" report and the "Experimental Factorial" were completed and submitted to MDT in October 2001. The factorial consists of 93 LTPP test sections of which 38 are in the State of Montana and the remaining 55 in neighboring States and Canada. In addition, 10 non-LTPP, supplemental sites were established and included in the factorial. These sites are: Condon, Deerlodge / Bechhill, Silver City, Roundup, Lavina, Wolf Point, Ft. Belknap, Perma, Geyser, and Hammond.

In March 2004, after a review of the results of the performance prediction analyses available to date, the team decided to include the two tentatively selected Superpave sites, Lothair and Baum Rd., in the group of non-LTPP sites. These sites were selected based on their geographical location and subgrade type in order to cover the whole range of climatic/subgrade conditions specific to Montana.

Task 4 – Develop Work Plan for Monitoring and Testing

Completed: A Work Plan was developed and provided to MDT in October 2001. The document contains the "Materials Sampling Plan," the "Initial Testing Plan" to document the baseline condition of each test site, the "Laboratory Testing Plan" to define the material properties and layer thickness at each test site, and the "Performance Monitoring Plan" to document time series data within the 60-month contract period.

PERFORMANCE MONITORING PLAN

The Performance Monitoring Plan was revised in a team meeting in March 2004 and is presented in Table 1:

Table 1. Performance Monitoring Activities

Activity	Available	Planned
<i>Distress Surveys</i>	June 2002, June 2003	June 2005
<i>FWD</i>	August 2001, April 2002, April 2004	March 2005
<i>Profile</i>	October 2001	2004, May 2005

FWD COMPARISON STUDY

A comparison study was performed on LTPP sections in Great Falls and Big Timber, Montana (May 6-May 19, 2004) in which Montana LTPP sections were tested in parallel with MDT's FWD equipment and LTPP's FWD equipment. The purpose of this comparison testing was to identify any bias that might exist between the FWDs used to measure deflection data on different test sections that will be used on this project. The hypothesis was that there is no bias between the two devices.

FWD testing was completed in May 2004. Deflection data was collected at 416 locations (station/lane) for 4 drop heights (load levels: 6, 9, 12, and 16 kip) and 9 sensors. The LTPP and MTDOT FWD equipment are using the same number of sensors and the same sensor spacing. Plots of deflections measured with the LTPP FWD versus the MDT FWD have been included in Appendix A of the August 2004 progress report.

The major conclusions of this comparison study are:

- In the great majority of the cases the LTPP equipment measured higher deflections when compared to the MDT equipment, for all sensors and all drop heights; the bias was higher for sensor 1 and decreasing as the distance from the load (sensor 1) increases
- The bias in the measured deflections appears to be significant; further analysis will investigate the corresponding bias in backcalculated modulus values
- A correction factor could easily be implemented by using a linear, two parameter equation
- Further testing is not likely to be necessary

The effect on backcalculated moduli values will be investigated during the next reporting period. A similar study for Profile equipment is desirable and will be planned.

Task 5 – Presentation of Work Plan to MDT

Completed: The Work Plan (PowerPoint) was presented to MDT by the project team in October 2001.

PHASE II

Task 6 – Implement Work Plan – Data Collection

LTPP SITES

There are 93 LTPP sites included in the experimental factorial. Of these, 38 are located in Montana and 55 in neighboring States and Canada. A set of queries was written that can be used at any time in the future to extract the data needed from the LTPP database to update the information in the calibration/validation database. The database is now complete and populated with LTPP data.

NON-LTPP SITES

The 10 non-LTPP sites are: Condon, Deerlodge / Beckhill, Silver City, Roundup, Lavina, Wolf Point, Ft. Belknap, Perma, Geyser, and Hammond. All testing related to the 10 sites is completed and the results have been presented in previous progress reports.

SUPERPAVE SITES

In addition to the 10 non-LTPP sites, two Superpave sites have been selected to be included in the testing/monitoring plan. These sites are Lothair and Baum Rd. Samples of materials from the two sites have been received from MDOT during 2003 and consist of binder cans, bags of bulk mix and buckets with unbound material. The materials have been stored off site in a temperature controlled storage room.

Binder testing results from Trumbull (Granite City, Illinois) for the three Superpave mixture tests were presented in the May 2004 monthly report. Resilient modulus testing for the unbound materials is completed and the results of the regression analysis are summarized in Table 2. Table 2 includes the results for all the unbound layers on the 12 non-LTPP sites.

Table 2. Resilient Modulus Results for non-LTPP Test Sites

<i>Material</i>	<i>n</i>	<i>k₁</i>	<i>k₂</i>	<i>k₃</i>	<i>R²</i>
Condon_Base	15	1,235	0.548	-0.497	0.90
Condon_Subgrade	15	1,568	1.007	-1.689	0.97
Deerlodge_Base	15	995	0.655	-0.533	0.89
Deerlodge_Subgrade	15	1,134	0.346	0.128	0.81
Ft Belknap_Base	15	928	0.671	-0.326	0.99
Ft Belknap_Subgrade	15	632	0.450	0.926	0.94
Geyser_Base	15	1,172	0.599	-0.474	0.96
Geyser_Subgrade	15	1,911	0.433	-0.317	0.96
Hammond_Base	15	896	0.586	-0.204	0.98
Hammond_Subgrade	13	2,669	0.764	-3.796	0.84
Lavina_Subgrade	14	1,825	1.130	-2.659	0.94
Perma_Base	15	803	0.565	-0.871	0.88
Perma_Subgrade	15	1,435	0.555	-2.539	0.94
Roundup_Subgrade	15	1,350	0.455	-1.160	0.93
Silver City_Base	15	1,091	0.648	-0.363	0.99
Silver City_Subgrade	15	1,548	0.491	-2.087	0.96
Wolf Pt_Subgrade	12	1,765	0.332	-1.000	0.71
Baum Rd CBC Base	15	1,697	0.637	-2.489	0.96
Baum Rd Subgrade	15	705	0.201	-1.098	0.76
Lothair CBC Base	15	1,325	0.650	-2.078	0.95
Lothair Special Borrow	15	456	0.864	-2.108	0.93
Lothair Subgrade	15	610	0.102	-0.991	0.79

Where $M_R = k_1 \cdot p_a \cdot (\theta/p_a)^{k_2} \cdot (\tau_{oct}/p_a + 1)^{k_3}$

For comparison, the regression parameters presented in Table 2 are used to estimate the resilient modulus at two typical states of stress, one for subgrades and one for base materials. These comparisons are shown in Figures 1 and 2.

NOTE: HMA cores are not available to test for indirect resilient modulus, tensile strength and creep. However, gradation, volumetric properties and viscosity can be used to predict the stiffness of the HMA layer using the "Witczak et al. Dynamic Modulus" predictive equation.

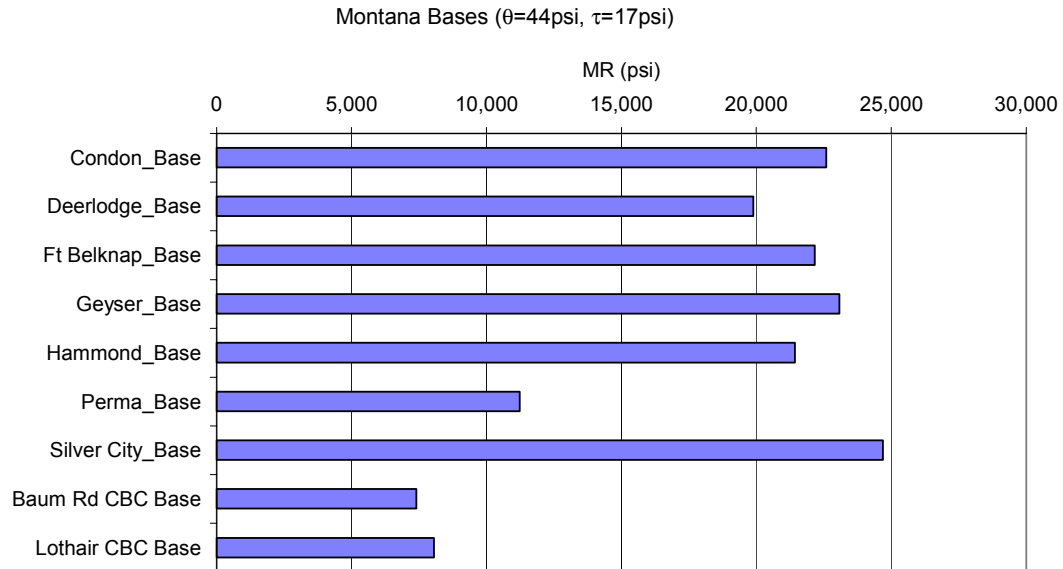


Figure 1. Resilient Modulus Comparison for Base Materials

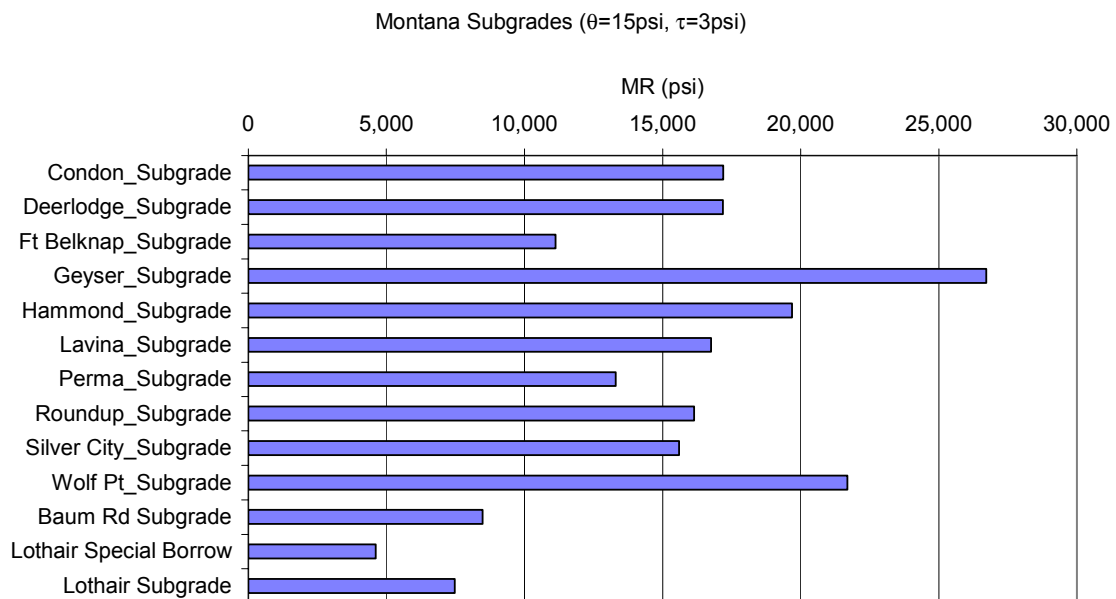


Figure 2. Resilient Modulus Comparison for Subgrade Materials

Task 7 – Data Analyses and Calibration of Performance Prediction Models

Completed: The calibration technique (or the specific steps required to determine calibration coefficients) was demonstrated to MDT utilizing models similar in nature to the NCHRP 1-37A *Mechanistic-Empirical (M-E) Pavement Design Guide* (initially titled *2002 Design Guide*) models. The project team made a presentation to the department in August 2003, which included a progress report, findings, and an illustration of the calibration exercise for the Silver City test section. A detailed discussion of the calibration algorithm accompanied by examples and step-by-step instructions will be included in a chapter of the Final Report.

In August 2004, a project meeting update and status report was held at MDT's headquarters. An overview of the work completed to date and a presentation on the calibration process as well as the results obtained to date were presented. A demonstration of the new *M-E Pavement Design Guide* software was provided to identify the complexity, detail of the inputs, and note some of the problems that will likely be encountered by the Department personnel in using the software for selected pavement types.

The calibration and validation database has been finalized and populated with LTPP data. The latest version of the calibration/validation database was given to MDT (CD format) at the August 24, 2004 meeting.

An initial performance prediction exercise was performed for the 10 non-LTPP experimental sites. Material test data together with historical traffic and climatic data were used to predict the performance of these sites in terms of fatigue cracking and rutting in the asphalt concrete layer and rutting in the base and subgrade layers. Predicted distress was compared to results of the two distress surveys available for these sites (June 2002 and June 2003) and to the rutting measurements taken in October 2001. The results of this exercise were included in the July-September 2003 Quarterly Report.

A second performance prediction analysis, similar to the one performed on the non-LTPP, was started on the LTPP experimental sites. The availability of LTPP data was investigated in parallel with this study. While the performance predictions could be done either by spreadsheets or using the M-E Design Guide software, the solution by spreadsheets was used primarily because the Design Guide software is not yet available. However, after a review and revision of the project budget this month, the study was suspended. The team considers that the performance predictions that will be performed using the M-E Design Guide software are of greater importance and the funds available will be allocated to this effort.

The review edition of the M-E Design Guide software was released by NCHRP mid-July. The research team used the software to begin the calibration analyses for the performance models included in the M-E Design Guide.

The project team will complete a simplified calibration exercise using the same distress prediction models, but in a more simplified manner so that MDT can use this information with their pavement management database. This activity will be demonstrated to MDT during the final meeting and will be included in the final report submitted for review.

Task 8 – Final Report and Presentation of Results

No activity.

PROBLEMS / RECOMMENDED SOLUTIONS

No problems were encountered during last month and none are anticipated next month.

NEXT MONTH'S WORK PLAN

The activities planned for next month are listed below:

- Coordinate with MDT personnel on an as-needed basis.
 - Continue the analysis of FWD testing data from Great Falls and Big Timber, Montana.
 - Analyze resilient modulus test results for Lothair and Baum Rd
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FINANCIAL STATUS

The Financial Summary I table shows the estimated expenses incurred during the reporting period.

The Financial Summary II table provides the total project expenditures by the Montana and FHWA fiscal years in comparison to the allocated funds for each fiscal year.

The Financial Summary III-A chart illustrates total expenditures from inception of the project June 2000 through December 2003. The Financial Summary III-B chart reflects total project expenditures from January 2004 to the end of the project, May 2006.

cc: Jim Moulthrop, Fugro
Dragos Andrei, Fugro
Amber Yau, Fugro
Veena Prabhakar, Fugro

Harold Von Quintus, ERES/ARA
Jon Watson, MDT
Greg Zeihen, MDT
Matthew Witczak, Consultant
Mark Hallenbeck, Consultant

Financial Summary I

Estimated Expenses for Reporting Period: Fugro-BRE

Cost Element	Last Month's Cumulative Project Costs, \$	Current Month's Expenditures, \$	Cumulative Project Costs, \$
Direct Labor	\$ 101,035.98	\$ 383.50	\$ 101,419.48
Overhead	\$ 144,481.33	\$ 548.41	\$ 145,029.74
Consultants/Subcontractors	\$ 53,577.03		\$ 53,577.03
ERES/ARA	\$ 31,220.04	\$ -	\$ 31,220.04
Parsons-Brinckerhoff	\$ 12,092.58	\$ -	\$ 12,092.58
SME	\$ 523.21	\$ -	\$ 523.21
Dr. Matthew Witczak	\$ 2,850.00	\$ -	\$ 2,850.00
Dr. Mark Hallenbeck	\$ 5,691.20	\$ -	\$ 5,691.20
Brent Rauhut	\$ 1,200.00	\$ -	\$ 1,200.00
Travel	\$ 14,607.23	\$ 899.80	\$ 15,507.03
Testing	\$ 75,464.58	\$ -	\$ 75,464.58
Other Direct Costs	\$ 6,946.56	\$ 112.95	\$ 7,059.51
Fee	\$ 38,928.41	\$ 194.47	\$ 39,122.88
TOTAL	\$ 435,041.12	\$ 2,139.13	\$ 437,180.25

Financial Summary II

Total Expenditures by Fiscal Year: Montana and FHWA

MONTANA DOT FISCAL YEAR			FHWA FISCAL YEAR		
FISCAL YEAR	Cumulative Allocated Funds, \$	Cumulative Expenditures, \$	FISCAL YEAR	Cumulative Allocated Funds, \$	Cumulative Expenditures, \$
6/1/2000-6/30/2001	\$ 15,000	*0	6/1/2000-9/30/2001	\$ 65,000	\$ 31,996
7/1/2001-6/30/2002	\$ 218,969	\$ 82,420	10/1/2001-9/30/2002	\$ 258,969	\$ 102,303
7/1/2002-6/30/2003	\$ 348,969	\$ 213,291	10/1/2002-9/30/2003	\$ 358,969	\$ 216,187
7/1/2003-6/30/2004	\$ 388,969	\$ 125,486	10/1/2003-9/30/2004	\$ 398,969	\$ 86,695
7/1/2004-6/30/2005	\$ 428,969	\$ 15,984	10/1/2004-9/30/2005	\$ 438,969	\$ -
7/1/2005-6/30/2006	\$ 498,969	\$ -	10/1/2005-9/30/2006	\$ 498,969	\$ -
TOTAL	\$ 498,969	\$ 437,181	TOTAL	\$ 498,969	\$ 437,181

*June 2001 expenditures were combined with July 2001 expenditures.

